# UNIT 3 - TECHNOLOGY
# SECTION 2 - START YOUR ENGINES

ALTERNATIVE ENERGY

## Vocabulary

| | | | |
|---|---|---|---|
| **adiabatic** | **cylinder** | **horsepower** | **power stroke** |
| **carburetor** | **exhaust stroke** | **intake stroke** | **pressure** |
| **compression ignition** | **external-combustion engine** | **internal-combustion engine** | **reciprocating engine** |
| **compression stroke** | **fuel injector** | **Otto cycle** | **rotary engine** |
| **crankshaft** | **generator** | **piston** | **spark plug** |

Energy comes to us in many forms. Usually, though, it does not come in the correct form to produce power for our transportation. A transportation device, such as a car, typically needs different types of power. For example, mechanical energy is needed to push a car forward. Electrical energy is required to operate its headlights.

**What is an engine?**

*Any device that can change energy into mechanical work*

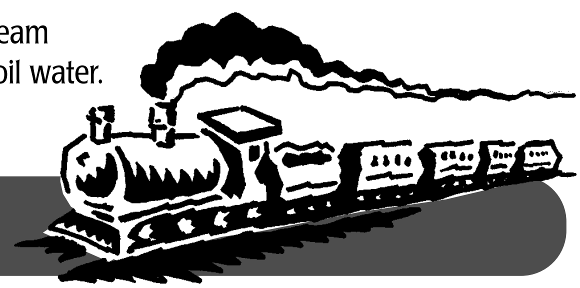
**Figure 3-2-1 What is an engine?**

Gasoline and diesel engines are examples of energy converters. Energy converters are designed to accomplish one purpose: to convert energy into useful work. Engines convert the energy stored in fuels into power or mechanical energy, which is used to operate the vehicle.

If you look under the hood of a car or a truck, you will see a heat engine. A heat engine is a device that uses heat energy to do work. The engine does work by changing heat energy into motion.

Basically, there are two types of heat engines: **external-combustion** and **internal-combustion**. Fuel for an external-combustion engine is burned outside the engine. Fuel for an internal-combustion engine is burned inside it.

Steam engines are external-combustion engines powered by steam produced outside the engine by using a fuel, such as coal, to boil water.

## Train of Thought

In 1769 James Watt invented a steam engine that was much more efficient than previous steam engines. Some people complained that early steam engines took an iron mine to build and a coal mine to run. Watt's new engine was able to do more work than previous engines for each kilogram of coal burned. The first steam locomotives, nicknamed "iron horses," quickly replaced animal power in moving goods and people.

Manufacturers of the machine decided to talk about their new product in terms of the horses it could replace. The unit **horsepower** was standardized by Watt to mean the amount of work a horse could deliver each second.

Today, the horsepower unit is used to rate the performance capability of electric motors and vehicle engines. One horsepower is the amount of power required to raise 550 pounds one foot in one second.

The internal-combustion engine is the most common type of engine used today. Typical automobile engines are internal-combustion engines, as are the engines in boats, lawn mowers, and home generators.

Internal-combustion engines may be either **reciprocating** or **rotary**. The reciprocating engine, with pistons that move back and forth, is the type used in most automobiles. In a rotary engine, such as a jet turbine, power is supplied directly to vanes or other rotating parts.

Most automotive engines have four basic parts: a **carburetor** or **fuel injector**, **pistons**, **cylinders**, and **spark plugs**. Fuel mixes with air in the carburetor or is sprayed through a fuel injector. The mixture goes into a cylinder, essentially a long air pocket, like a steel can with one end open. In a spark-ignition engine, the mixture is ignited by a spark from the spark plug, releasing heat. This heat increases the **pressure** inside the cylinder. This moves the piston, a metal plug that fits snugly into the cylinder but is loose enough to slide up and down.

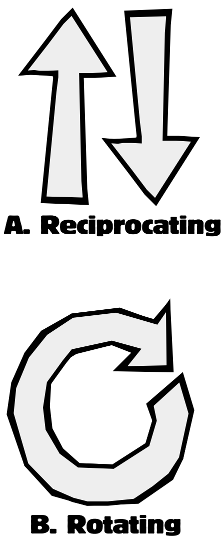



**Figure 3-2-2**
*Reciprocating motion is up and down, or back and forth, as contrasted with rotary (rotating) motion*

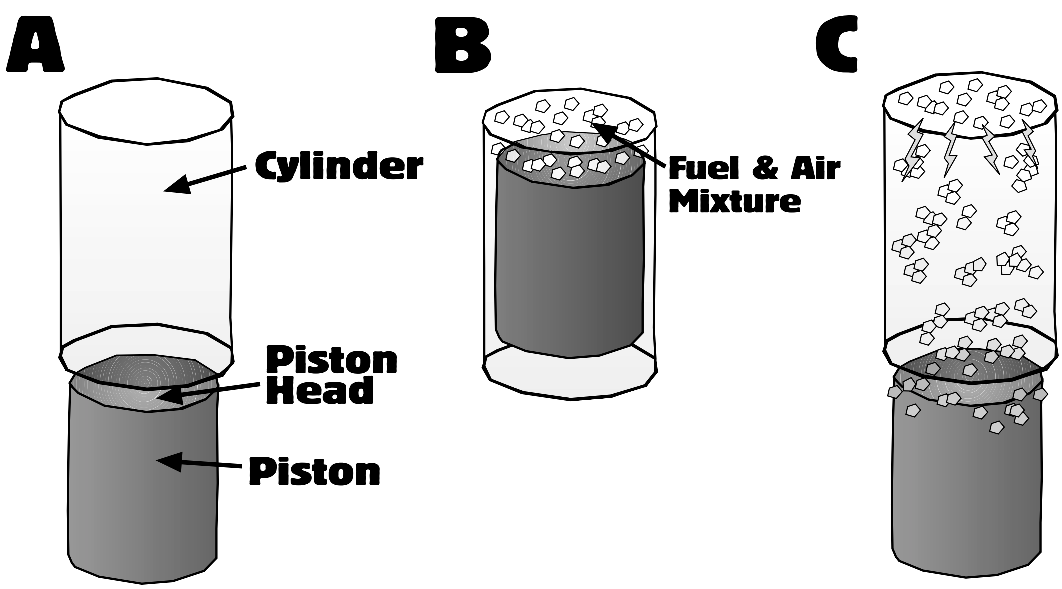



**Figure 3-2-3 Three views showing the action in an engine cylinder**
a) *The piston is a metal plug that fits snugly into the cylinder.*
b) *When the piston is pushed up into the cylinder,the fuel/air mixture is trapped and compressed. (The cylinder is drawn as though it were transparent, so the action can be seen.)*
c) *The increase in pressure as the mixture of air and gasoline ignites pushes the piston down in the cylinder.*

How does this increase in pressure produce energy of motion? Think of it like this: Suppose you boil water in a covered pot. The boiling water changes to steam, a gas, which takes up more room than the liquid. So, the pressure increases. If the cover is not attached tightly to the pot, the increased pressure forces it up. You can see the cover on a pot of boiling water move upwards. The rattling of the lid is the intermittent release of pressure.

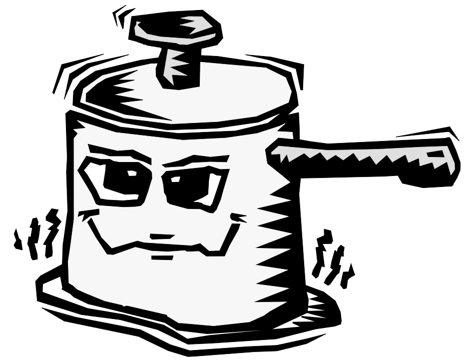


**Figure 3-2-4** *When water boils in a covered pot, pressure increases and causes the cover to move upward.*

When a piston in an engine is pushed up into its cylinder, the upward movement traps the mixture of air and fuel above it and compresses it to one-eighth or one-ninth of its original volume. This puts the molecules closer together, so they hit the piston head far more often. Thus, the pressure goes up.

When the mixture is ignited, a controlled explosion occurs that makes the molecules move even faster. They bombard the piston head still harder. These billions of molecules, moving at great speeds, hit the piston head so hard and so often that they add up to a total push of a ton or more. This push or pressure is due only to the pounding of the fast-moving molecules.

## Blown Away

The process of compression or expansion of a gas so that no heat enters or leaves a system is said to be **adiabatic**—meaning heat cannot pass in or out. Adiabatic changes can be achieved in two ways. One is by performing the process rapidly, so that heat has little time to enter or leave. Another is by thermally insulating a system from its surroundings.

When work is done on a gas by adiabatically compressing it, the gas gains internal energy and becomes warmer. When a gas adiabatically expands, it does work on its surroundings and gives up internal energy, thus becoming cooler.

A common example of an adiabatic process is the compression and expansion of gases in the cylinders of an automobile. In hundredths of a second, compression and expansion occur, too short a time for heat energy to leave the combustion chamber. Under high compression, as in diesel engines, the temperatures achieved are high enough to ignite a fuel mixture spontaneously—without the use of spark plugs.

You can demonstrate an adiabatic process right now. Blow warm air onto your hand from your wide-open mouth. Now reduce the opening between your lips so the air expands as you blow. Adiabatic expansion causes the air to be cooled.

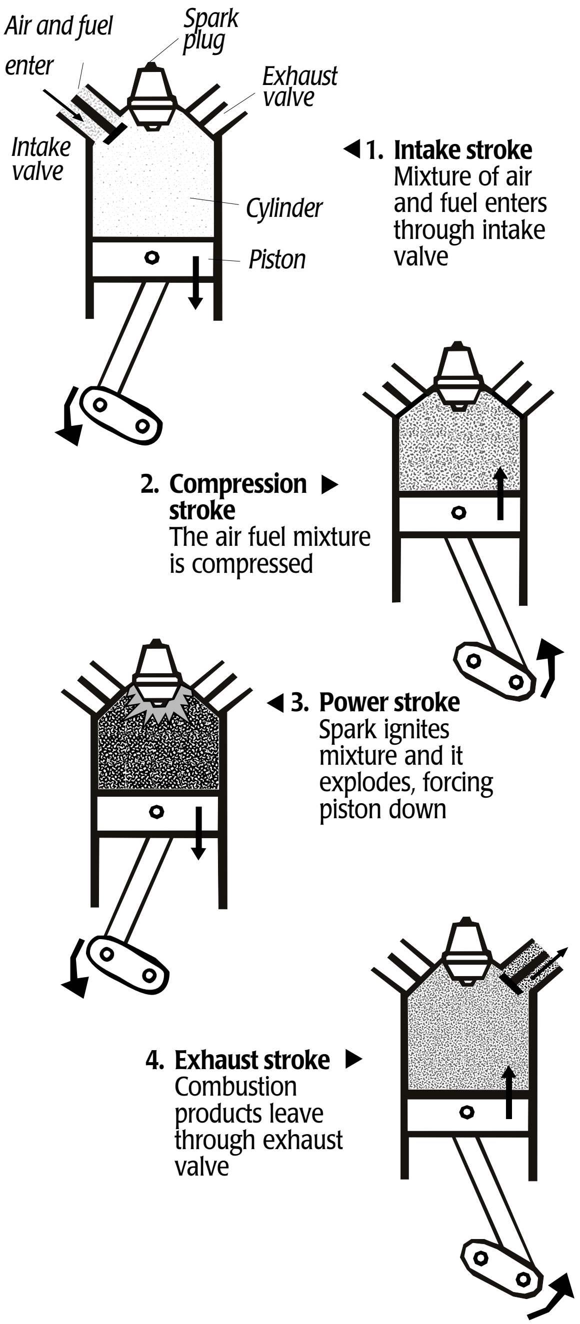



**Figure 3-2-5 The four strokes of an Otto-cycle engine**

As the piston is pushed down in the cylinder, other engine parts keep it from blowing out of the cylinder. The piston is then pushed back up into the cylinder.

The up-and-down motion of the piston in the cylinder must be changed to turning, or rotary, motion for the wheels. The downward movement of the piston pushes a rod that turns a **crankshaft**. The turning crankshaft provides the motion to turn the wheels. Thus, the reciprocating motion of the piston is changed to rotary motion.

Most automobiles have an even number of cylinders. The controlled explosion in each cylinder occurs at a different time. The explosions provide the work to move the automobile.

An internal-combustion engine employs either a four-stroke cycle or a two-stroke cycle. In the four-stroke cycle, also known as the **Otto cycle**, the downward movement of the piston within a cylinder creates a partial vacuum. For the **intake stroke**, a fuel-air mixture fills the vacuum in the cylinder as the piston moves down. During the **compression stroke**, the piston moves up and compresses the mixture. The spark plug fires, the mixture ignites and forces the piston down in the **power stroke**. The combustion products are pushed out the exhaust valve in the **exhaust stroke**. Then the cycle repeats.

Diesel engines, like the gasoline engine, have cylinders and pistons and burn a liquid fuel. They may use either a two- or four-stroke cycle. Diesel engines' main difference from gasoline engines is that there is no electrical spark to ignite the fuel. Ignition occurs spontaneously when the air-fuel mixture reaches the right temperature and pressure.

Two-stroke engines only require two strokes to complete the combustion cycle. They are commonly found in lower-power applications such as lawn and garden equipment and smaller motorcycles.

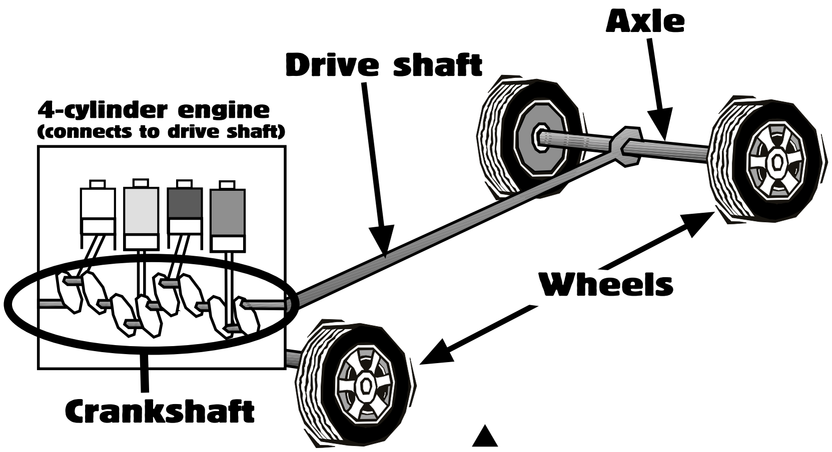



**Figure 3-2-6 A four-cylinder engine connected to a crankshaft**

## FYI: Early Auto Engines

The development of internal-combustion engines is usually credited to four Germans. Nikolaus Otto patented and built the first such engine in 1876. Karl Benz built the first automobile to be powered by such an engine in 1885. Gottlieb Daimler designed the first high-speed internal-combustion engine and carburetor in 1885. Rudolf Diesel invented a successful **compression-ignition** engine (now known as the diesel engine) in 1892.

## FYI: Mix It Up

In a gasoline engine, a mixture of air and fuel vapor is compressed and then ignited. Air is about 20 percent oxygen and about 80 percent nitrogen. Gasoline is mostly hydrogen and carbon. In the engine, oxygen atoms unite with the hydrogen atoms in the gasoline to form water ($H_2O$). Oxygen atoms also unite with carbon atoms to form carbon dioxide ($CO_2$). During combustion, temperatures may get as high as 6000° F. At such high temperatures, nitrogen combines with oxygen, producing nitrogen oxides ($NO_X$) pollution.

In ideal (perfect) combustion, all the hydrocarbons in the gasoline would be made into $H_2O$ and $CO_2$. However, engines do not produce ideal combustion. Some hydrocarbons are left over. Also, some poisonous carbon monoxide (CO) is produced instead of $CO_2$. These products contribute to air pollution.

# Start Your Engines Resource List

http://umdgrb.umd.edu/~goodman/engines/engines.html
University of Maryland, College Park
Animation showing how a four-cycle internal-combustion engine works.

http://www.howstuffworks.com/engine.htm
Howstuffworks.com, Inc.
Animation showing how an internal-combustion engine works, its parts, and how to help an engine produce more power.